Attentional responses to stimuli associated with a reward can occur in the absence of knowledge of their predictive values

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Attentional responses to stimuli associated with a reward can occur in the absence of knowledge of their predictive values

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[1] Abbreviations:
CS – Conditioned Stimulus
EC – Evaluative Conditioning
CA – Contingency Awareness
IAT – Implicit Association Test
HR – High-reward
LR – Low-reward
RSVP – Rapid Serial Visual Presentation
AUDIT – Alcohol Use Disorders Identification Test
AUQ – Alcohol Use Questionnaire
EAB – Emotional Attentional Blink
B – Bayes Factor
SDT – Signal Detection Theory
H – Hits
CR – Correct Rejections
FA – False Alarms
M – Misses
OD – Odds Ratio
SE – Standard Error

Abstract

Classical conditioning theories of addiction suggest that stimuli associated with rewards acquire incentive salience, inducing emotional and attentional conditioned responses. It is not clear whether those responses occur without contingency awareness (CA), i.e. are based on explicit or implicit learning processes. Examining implicit aspects of stimulus-reward associations can improve our understanding of addictive behaviours, supporting treatment and prevention strategies. However, the acquisition of conditioned responses without CA has yet to be rigorously demonstrated, as the existing literature shows a lack of methodological agreement regarding the measurement of implicit and explicit processes.

The purpose of two experiments presented here was to study the emotional value acquired by CS through implicit emotional and attentional processes, trying to overcome critical methodological issues.

Experiment 1 (n=48) paired two stimuli categories (houses/buildings) with high (HR) or low (LR) probabilities of monetary reward. An Emotional Attentional Blink revealed preferential attention for HR over LR regardless of CA; while pleasantness ratings were unaffected, probably due to the intrinsic nature of CS.

Experiment 2 (n=60) replicated the effect of conditioning on the Emotional Attentional Blink utilising abstract CS (octagons/squares). In addition increased pleasantness for HR over LR was found significant overall, and marginally significant for Aware but not for Unaware participants. Here CA was rigorously determined using a signal-detection analysis and metacognitive-awareness measurements. Bayesian analyses verified the unconscious nature of the learning.

These findings demonstrate that attentional conditioned responses can occur without CA and advance our understanding of the mechanisms by which implicit conditioning can occur and becomes observable. Furthermore, these results can highlight how addictive behaviours might develop.

Keywords:

Implicit Conditioning; Attentional Blink; Pleasantness; Contingency Awareness; Metacognition; Bayesian

Statement:

Participants provided informed consent to take part in this experiment. Ethical approval was granted by the University of Sussex Life Sciences ethics committee. We declare no conflicts of interest in the development of this research.

1. Introduction:

Processes related to Classical conditioning have been proven to determine the development of addictive behaviours. Stimuli conditioned (CS) with addictive drugs acquire hedonic and reinforcing properties associated with the substance [1, 2], ultimately driving and maintaining drug-seeking behaviours. As part of this process, drug-related cues generate preferential attention and emotional ratings in heavy drinkers of alcohol, cocaine addicts [3] and smokers [4, 5]. Most of the conditioned responses occur with subjects' awareness [6], as substance expectancy generated by drug-paired stimuli is responsible for attentional, instrumental and hedonic conditioned responses [7]. However, conditioned responses may also occur without subjects' awareness, and could be studied from an implicit point of view.

The study of implicit processes within addiction has gained increasing relevance, as pointed by Wiers and Stacy [8], leading to dual-process theories of addiction. Dual process theories of addiction conceptualize addictive behaviours as the combination of automatic appetitive appraisals generated by associations [9] in opposition to regulatory executive signals based on propositional knowledge [10]. However, the model presented by Wiers and Stacy does not specify the nature (implicit and/or explicit) of the associations generating automatic responses, obviating the role implicit learning may have in the development of automatic responses towards drug related stimuli. Determining the extent to which implicitly generated associations can induce conditioned responses without awareness could provide a better understanding of addictive behaviours.

Implicit processes in addiction are most commonly studied via attentional bias measurements, memory associations or action tendencies [8] using naturalistic stimuli, materials conceptually related to a substance. The use of naturalistic stimuli we think is a limitation, as the explicit conceptual representation of the substance is necessarily bounded to drug-related stimuli, compromising the dissociation between implicit and explicit processes even in automatic detection tasks.

Neutral cues paired with alcoholic drinks or tobacco can also generate attentional and autonomous reactions through classical conditioning [11, 12]. Furthermore, stimuli associated with non-drug rewards can also be conditioned to generate incentive responses equivalent to those elicited by drug-related stimuli [13]. Given that CSs in this case are originally devoid of any motivational attributes, conditioning paradigms can provide an opportunity to investigate the development of implicit (as well as explicit) processes through learned associations between such stimuli and rewards in the laboratory.

Within the Evaluative Conditioning (EC) paradigm, the modification or generation of emotional responses towards cues paired with positively or negatively valenced stimuli [14], has led to confronting viewpoints about the necessity of learning to be conscious in order to elicit measurable responses. A meta-analysis [15] showed that pleasantness can occur without Contingency Awareness (CA), that is, without conscious knowledge, i.e. knowledge that the neutral CS had been associated with a highly emotional stimulus. However, opposing views are still prevalent [16, 17]. Whether conditioning can occur without CA has generated a discussion regarding the methods most appropriate to measure implicit [18], or explicit knowledge about contingencies [19].

Furthermore implicit learning in Pavlovian conditioning tasks is most commonly demonstrated using direct self-report measurements of liking [20, 21]. This type of assessment is based on Likert or Visual Analog scales in which participants evaluate the pleasantness of a stimulus. De Houwer [22] however, has advocated for the need to study emotional reactions in the context of Implicit learning through indirect measures of automatic behaviour.

Attentional processes are strongly affected by the emotional salience of stimuli (see [23] for a review), and attentional correlates of conditioned stimuli have been employed in Pavlovian conditioning procedures. Hogarth et al, has demonstrated attentional orientation to stimuli associated with a monetary reward versus non-reward using eye tracking [7], whereas Anderson, Laurent, and Yantis [24] showed that stimuli paired with high-reward (HR) versus low reward (LR) probabilities were more distracting on a visual search task. Automatic attention allocation towards CS has also been demonstrated using rapid serial visual presentation tasks (RSVP). In this kind of task, also known as Attentional Blink [25], a stream of pictures is presented and participants have to detect a target embedded within the stream. Before the target, a distractor is also presented, affecting the accuracy on detection of the target. Emotional Attentional Blink (EAB) tasks [26] employ emotional stimuli as distractors during the RSVP.

Conditioned stimuli have been used during RSVP tasks both as distractors during an aversive conditioning task [27], and as targets during a task irrelevant Pavlovian conditioning procedure [28], providing evidence towards the ability of CS to capture attention. However, no measures of CA (see below) were included in this task. Thus, it cannot be excluded that the ability of the CS to guide attention is based on explicit knowledge about stimulus-outcome contingencies, a matter that will be addressed in this paper.

Measurements of CA in Pavlovian Conditioning are often based on post-hoc ratings, i.e. asking participants how stimuli and outcomes were related to each other during learning. Lovibond and Shanks [19], proposed as the most valid measures of CA to ask participants on a trial by trial basis to anticipate the outcome using Likert or Visual Analogue Scales in the presence of CS. Several studies have considered such criteria for measures of Expectancy Awareness (e.g. [21, 29]) showing that pleasantness ratings for the CS can occur in the absence of CA. Others have appealed to retrospective measurements when measuring CA [30]. These differences in terms of CA measurement could in turn explain the inconsistencies found in experimental literature related to Implicit Conditioning [16].

Prior literature in the field of Implicit learning has primarily focused on artificial grammar-learning tasks [31, 32] and sequence learning [33], but few studies have used self-reports in conditioning experiments [34, 35]. In these latter studies, however, no implicit conditioned responses were found.

Measures of CA and Implicit learning as previously described respond to the criteria set out by classical implicit learning theories [32] in which objective measurements (i.e. accuracy on a detection task) are combined with subjective evaluations (i.e. ability to report a rule). However, a third layer of measurement can be implemented, testing whether participants have developed Metacognitive awareness about their knowledge of the set of rules underlying the procedure, that is, whether they can explicitly report those rules [36, 37].

To our knowledge, there are no studies which have successfully incorporated the criteria set out by Dienes and Perner [36] for a distinction of explicit from implicit knowledge using Metacognitive measures (e.g. [38, 39]) within a Pavlovian conditioning task.

The purpose of this paper was to examine if stimuli conditioned to a reward outcome would implicitly generate attentional and/or emotional conditioned responses. A task irrelevant conditioning task was used to limit the extent to which participants reached CA. An EAB studied the ability of CS to overcome the effect of emotional distractors, therefore assessing their ability to generate preferential attention. In this kind of task, aversive distractors decrease the accuracy on detection of targets compared to neutral distractors. We hypothesize that detection of LR stimuli will decrease when distractors are aversive compared to when they are neutral, an effect that should be weaker for HR stimuli. This would show HR stimuli develop preferential attention as they are able to overcome the effect of negative distractors.

A novel approach for conditioning learning was employed in Experiment 2 following methods originating from the Implicit Learning literature [40], to classify participants in different groups

according to their awareness level. Three levels of CA were hypothesized: complete Unawareness of Contingencies; Partial Awareness, being able to predict the nature of an outcome without explicit knowledge about it; and Metacognitive Awareness, in which explicit knowledge about the contingencies is developed.

2. EXPERIMENT 1:

2.1 AIMS

The aim of this first experiment was to examine the occurrence of implicitly conditioned responses. Particularly, we assessed whether awareness about contingencies between CS and its outcome is necessary to develop preferential attention towards stimuli predicting higher chances of reward. Another focus of the experiment was to investigate whether this preferential attention occurs together with a development of Pleasantness towards the aforementioned stimuli.

2.2 METHODS

2.2.1 Participants:

Forty Eight University of Sussex students (28 females), mean age 22.7 years, were recruited via an online participant database and compensated for their time financially or with course credit. Participants gave written consent before beginning the study, with ethical approval being granted by the University of Sussex Life Sciences ethics committee. Inclusion criteria were that they were in a state of good health, whereas exclusion criteria were that they were currently taking prescription medication (excluding the contraceptive pill) or reported having been diagnosed with a mental illness.

2.2.2 Apparatus and stimuli:

During the conditioning phase, pictures depicting Buildings or Houses (36 of each category) were used as CSs throughout the experiment. Pictures were selected to be neutral with regard to pleasantness ratings of a pool of 50 House and 50 Building pictures before the experiment. An independent sample (n=16) rated the pleasantness of the pictures via Likert scales (from 1 to 9). From each category, 14 pictures with the highest deviation in pleasantness ratings from the mean were excluded to generate a definitive final list of 72 stimuli as neutral as possible. No significant differences in Pleasantness between Houses (5.14, SD=.86) and Buildings (5.14, SD=.56), were found $p>.538$. Pleasantness towards the selected Houses and Buildings was measured also by a larger independent sample of participants (n=40) to confirm stimuli similarity. No significant differences were found between Houses (5.01, SD=.89) and Buildings (4.83, SD=.97) regarding pleasantness, $p>.3$.

During the Emotional Attentional Blink stimuli were used as targets among a series of picture fillers, composed by 4x5 matrices of Houses and Buildings (see Fig. 2 for an example). Distractors, aversive and neutral pictures, were obtained from the IAPS picture data base [41] with additional matched aversive pictures from the internet.

Stimuli were presented on a Dell ACPI 64-bit PC, screen refresh rate= 16.6ms. Procedures were performed using E-prime 2. Data analysis was performed using SPSS and Matlab.

During the conditioning phase 10, 20 and 50p coins were used as tangible reinforcers at the end of each block.

2.2.3 Procedure:

Participants following informed consent completed questionnaires regarding their demographics and drug use, the AUQ [42] and AUDIT [43] questionnaires measuring alcohol consumption, the BIS-11 impulsivity questionnaire [44], the BIS BAS questionnaire on

approach-avoidance behaviours [45] and the PANAS mood questionnaire [46]. Participants also took an Interoception Assessment involving Heartbeat measurements [47], not described in this paper. Afterwards, they completed Conditioning, Emotional Attentional Blink and Pleasantness measurement tasks.

The experiment lasted approximately 80 minutes.

2.2.4 Conditioning task:

A task irrelevant Conditioning procedure was used to pair stimuli belonging to one of the categories (Houses vs. Buildings) with high (80%) or low (20%) probabilities of obtaining 10p [28]. For half of the participants, High Reward probability (HR) stimuli consisted of Houses and Low Reward probability (LR) stimuli consisted of Buildings, and vice versa.

CSs appeared on screen with an overlaid green or yellow square for 2000 ms or until a response was recorded (max recorded time 1499 ms). Participants were instructed to press a green or yellow key on the keyboard depending on the colour of the square. Participants were also informed that from time to time they would obtain money but were kept naïve about the nature of stimuli predicting reward or about the contingencies between stimuli and reward. As this conditioning procedure was task-irrelevant, the stimulus category (House or Building) was the only factor predictive of reward. Feedback was on screen for 1500 ms indicating whether the participant had obtained 10p or nothing on that particular trial.

Following correct responses to the yellow or green key participants were asked to indicate on a Likert scale from 1 to 9 how likely they were to win 10p whilst the stimulus remained on the screen (measurement of expectancy Awareness (EA)). Immediately after the response, they received feedback about the outcome of the trial (Fig. 1). Only in 25% of the Conditioning trials EA was measured as a means to avoid excessive priming towards contingency elaboration [19]; EA evaluation was pseudorandomized to occur every 3, 4 or 5 trials to prevent participants from establishing rules regarding its measurement. Trial order was pseudorandomized so the same kind of CS (HR/LR) or the same coloured square could not appear more than 4 times in a row.

In total 5 blocks of 72 trials were presented. At the end of each block the total amount earnt appeared on screen and participants had to grab the equivalent amount in coins and transfer it from a Bank box to their earnings box.

2.2.5 Emotional Attentional Blink:

After the Conditioning task, participants took the Emotional Attentional Blink. The purpose of this task was to evaluate the ability of CS to overcome the influence of aversive distractors.

Each trial consisted of a RSVP of 17 stimuli. Fillers composed of jittered matrices of Houses and Buildings appeared at the beginning of the trial. Aversive or neutral distractors appeared on the 4^{th}, 6^{th} or 8^{th} position of the series, followed by another filler and the presentation of the target, a HR or LR CS. Such a short lag between distractor and target was used as a means to increase the interference of distractors [48]. Finally, more fillers were presented to complete the stream of 17 images.

Participants were notified they would not be able to obtain money any longer and instructed to detect the presence in the stream of a House or a Building. At the end of each trial they had to press one of two keys depending on the category of the target detected.

The task started with a practice block of 12 trials in which each stimulus appeared on screen for 100 ms and feedback about accuracy was presented after each response.

The main task consisted of 3 blocks of 48 trials. Presentation time of each stimulus was 83 ms for participants with accuracy on detection above 75% on the practice block, and 100 ms for those less accurate (Fig. 2).

The amount of trials displaying aversive or neutral distractors was equally distributed among target type and no feedback was displayed during the task.

2.2.6 Pleasantness measurement:

At the end of the experiment CS pleasantness was measured via Likert scale. Eighteen House pictures and 18 Building pictures from the stimuli presented during conditioning appeared in random sequence on screen and participants had to indicate from 1-9 how pleasant each of them was. Each of the pictures remained on screen until response.

2.2.7 Data analysis

2.2.7.1 Expectancy evaluation:

First, participants were categorized as Aware or Unaware of the contingencies associated with CS depending on their responses to EA assessment. One sample t-test comparisons were performed both for the 4th and 5th block of trials (9 ratings per stimulus per block). Participants were deemed to be Aware if their expectancy ratings were significantly above 5 for the HR and below 5 for the LR stimuli on one of these blocks of trials; 5 was the rating denoting "I don't know". On the basis of this approach only 4 participants were classified as aware. Therefore data only from the Unaware participants are presented. Data on pleasantness for Aware participants are presented in Appendix A.

2.2.7.2 Emotional Attentional Blink (*EAB):*

Accuracy on detection of targets was the dependent variable for the EAB analysis; a 2-way Repeated measures ANOVA was conducted with CS target (HR vs LR) and distractor type (aversive vs. neutral) as within subject factors for Unaware participants. Planned post-hoc t-tests will examine the hypothesized detrimental effect of aversive distractors on detection of LR and HR targets. Differences between HR and LR targets under baseline condition (neutral distractors) were also explored using paired t-test. Descriptives for Aware participants are included in Appendix A.

2.2.7.3 Pleasantness:

Paired samples t-tests compared pleasantness ratings towards HR and LR stimuli for Unaware participants. Descriptives for Aware participants are included in Appendix A.

2.2.7.4 Supplementary analyses:

RT towards HR and LR stimuli during conditioning were log transformed in order to compare them. Paired samples t-tests were performed for Unaware participants, see Appendix A.

2.3 RESULTS:

2.3.1 Outcome expectancy measurements:

Out of 48 participants, only five met the two awareness criteria (Blocks 4&5, HR=5.19, SD=.78; LR=4.4, SD=1.24) and were classified as Aware. The rest, 43 participants, were considered Unaware of the contingencies associated with CS (Blocks 4&5, HR=5.42, SD=1.72; LR=5.4, SD=1.72).

2.3.2 Emotional Attentional Blink:

There was a significant interaction between target and distractor type for Unaware participants, $F(1,43)=6762$, $p=.013$. Detection of LR stimuli was significantly lower when distractors were aversive compared with neutral, $t(43)=2.796$, $p=.008$; this was not the case for HR stimuli. Only a marginal effect was found with higher detection for HR when distractors were negative compared to neutral, $t(43)=1.821$, $p=.076$. There were no significant differences between HR and LR targets under neutral distractors, $t(43)=1.085$ $p=.284$.

2.3.3 Pleasantness measurement:

No significant differences between HR and LR stimuli in terms of pleasantness $t(43)=.273$, $p=.786$, were found for Unaware participants, see Fig. 4.

In order to understand the inability of HR stimuli to generate preferential pleasantness, an exploratory analysis examined pleasantness development depending on stimulus category (Houses vs. Buildings) for Unaware participants. A paired samples t-test found that Houses were evaluated as more pleasant than Buildings when they were HR stimuli, $t(20)=2.687$, $p=.014$, but also when they were associated with LR, $t(22)=2.915$, $p=.008$, see Fig. 5. This might be due to an effect of the intrinsic value of CS, which may be higher for stimuli more related to comfort (Houses), than work and business (Buildings). No differences in pleasantness ratings were found between the two types of stimuli outside the conditioning procedure (see 2.2.2 Apparatus and Stimuli).

2.3.4 Questionnaires:

There were no significant differences between the Contingency Aware and Unaware groups and questionnaire scores (see Table A.1 in Appendix A).

2.3.5 Supplementary analyses:

No significant differences were found, see Appendix A.

2.4 DISCUSSION EXPERIMENT 1:

The present task irrelevant conditioning procedure induced expectancy awareness in only 4 out of 48 participants using probabilities of reward of 80% for HR and 20% for LR stimuli. As predicted, when measuring attentional preference towards HR CS compared to LR CS, HR stimuli were more resistant to the interference of aversive distractors than LR stimuli regardless of expectancy awareness. These results replicate those obtained by Yokoyama et al. [28], who did not, however, measure CA. These findings accurately show that CS acquire implicit incentive salience, which attracts attention, thus providing evidence towards the ability of implicit processes to govern the development of conditioned responses.

Concerning pleasantness, neither Aware nor Unaware participants developed preferential subjective pleasantness towards HR stimuli. One reason that Unaware participants failed to develop heightened pleasantness towards HR stimuli compared to LR might be the nature of the stimuli used during the conditioning task. Despite independent measures of pleasantness revealing no differences between Houses and Buildings, after the conditioning task Houses were evaluated as more pleasant than Buildings overall. It is possible that the intrinsic preference for Houses as a safe and comfortable space opposed to Buildings as workspace, in conjunction with the monetary conditioning procedure, overrode the development of contingency congruent hedonic responses in Unaware participants.

Importantly the classification of Aware and Unaware participants did not take into account metacognitive awareness measures and the criteria used to separate Aware from Unaware participants may have been therefore not rigorous.

In order to tackle these issues, Experiment 2 was designed to replicate Experiment 1 using abstract geometric shapes devoid of any intrinsic positive meaning and confidence ratings of awareness were introduced to classify participants more rigorously as Aware and Unaware.

3. EXPERIMENT 2:

3.1 AIMS

The second Experiment addressed some of the limitations of Experiment 1, aiming at strengthening evidence towards the existence of implicit emotional and attentional conditioned responses.

By implementing abstract stimuli instead of Houses and Buildings, we tried to come up with a Conditioning procedure able to generate Pleasantness towards HR CS together with preferential attentional salience on participants Unaware of the contingencies.

In addition, we aimed to improve our classification of participants to different degrees of awareness by incorporating confidence ratings on each EA measurement. With this addition we hoped participants could be classified in different levels of CA, from unawareness to Metacognitive Contingency Awareness, fulfilling criteria established in the Implicit learning literature [49]; Bayesian factors were introduced to determine the presence of unconscious processes [50].

3.2 METHODS

3.2.1 Participants:

Sixty Sussex University Students (52 females, mean age= 20.51, SD= 3.41) took part in the experiment. Participation conditions were identical to those of Experiment 1.

3.2.2 Apparatus and stimuli:

Two types of abstract stimuli were used as CS in this experiment, Squares and Octagons. A set of 72 stimuli was developed using InkScape software. Stimuli consisted of Octagons or Squares filled with parallel stripes. In order to generate different stimuli belonging to the same category (Squares or Octagons), 5 filling patterns were developed, differentiated in terms of stripe thickness. Then, each of the patterns was rotated multiple times, avoiding vertical and horizontal orientations as well as alignment with the edges of the figure contour [51]. This way, 36 Squares unique in terms of filling orientation and pattern and 36 matched Octagons were obtained. As this conditioning procedure was task-irrelevant, the stimulus category (Squares or Octagons) was the only factor predictive of reward.

The EAB fillers consisted of geometrical figures combining the contour of a Square and an Octagon, filled with the same patterns as CS.

During all the procedures, geometrical shapes were presented superimposed on neutral landscape pictures to match the visual characteristics of aversive and neutral distractors. For that purpose, 15 neutral pictures were selected from the internet to compose the background on each presentation. For examples of fillers and conditioning stimuli see Figure 6. Distractors consisted of the aversive and neutral stimuli as used in Experiment 1. The rest of the apparatus was identical to Experiment 1.

3.2.3 Procedure:

The procedure was similar to Experiment 1, except for the fact that Pleasantness measurements took place after the Conditioning task, and an extra measurement of Post-hoc EA was included at the end of the experiment.

3.2.4 Conditioning task:

A task irrelevant conditioning was employed as in Experiment 1, with Squares and Octagons as HR or LR CS. In order to increase the proportion of Aware participants, the probability of obtaining 10p after a HR stimulus was raised to 90% and decreased to 10% for LR.

EA was measured via a dichotomous question (“Will you get money?” – Yes/No) on 25% of the trials. After their response participants had to indicate how confident they were in their judgment using a 1-5 Likert scale, (1. “completely guessing”, 2. “more or less guessing”, 3. “fairly sure”, 4. “almost certain”, 5. “completely certain”). The two different types of

measurement, dichotomous and Likert, were employed to reduce interference between the two responses. The rest of the procedure was the same as in Experiment 1.

3.2.5 Pleasantness measurement and Emotional Attentional Blink:

The procedure was equivalent to the one used in Experiment 1, this time using the set of stimuli described above. Pleasantness was measured before the EAB.

3.2.6 Post-hoc Expectancy Measurement:

Expectancy was measured again at the end of the experiment using a 1-9 Likert scale to compare dichotomous online expectancy measurements with post-hoc assessments. Eighteen CS for each category were presented and participants asked to indicate how likely they thought they were to earn money after each of them. With this confirmatory analysis we aimed at reducing regression to the mean effects due to post-hoc categorizations [52].

3.2.7 Data analysis:

3.2.7.1 Bayesian analysis:

A Bayesian analysis [53, 54] allows determining the sensitivity of results obtained and extracting scientific conclusions from non-significant results. A Bayes factor (*B*) below 1/3 provides substantial evidence for the null hypothesis (i.e. there is no difference between two means) and a *B* above 3 shows substantial evidence for the alternative hypothesis. Results between 1/3 and 3 indicate data are insensitive. These factors will be used throughout these analyses as the main source of CA categorization.

3.2.7.2 Contingency Awareness:

Claiming that learning occurs implicitly requires accepting the null hypothesis that participants have not been able to perform above chance level on the task. Orthodox statistics based on p-values do not permit the validation of such claims [50]. Therefore, a Bayesian approach will be used to establish the existence of unconscious states [55].

In this experiment CA categorization was performed using Signal Detection Theory (SDT) methods [37, 56]. In order to compute participants' accuracy taking into account response bias, log Type I d' (d1') scores for each participant were computed, using the number of individual Hits (H, answering Yes on a HR trial), Correct Rejections (CR, answering No on a LR trial), False Alarms (FA, answering Yes on a LR trial) and Misses (M, answering No on a HR trial) [57]. Only results from blocks 4 and 5 were considered to account for the progressive development of learning.

In order to run a Bayesian analysis at an individual level for each participant, logistic d1' using Odds ratio (OR) (1) and Standard Errors (SE) (2) [58] were computed for each participant:

$$log_{d1'} = ln(OR) * \frac{\sqrt{3}}{\pi} \quad (1)$$

$$SE_{d1'} = \sqrt{\frac{1}{H} + \frac{1}{CR} + \frac{1}{FA} + \frac{1}{M}} * \frac{\sqrt{3}}{\pi} \quad (2)$$

Type II d' (d2') scores [59] allow determining metacognitive knowledge using accuracy and confidence responses for each participant. Each of the confidence ratings was converted from Likert scales (1-5), to a dichotomous variable (confident/not confident). Responses

equal to or below 2 (“more or less guessing”), were considered to be “low confidence”, the rest of the responses were considered as “confident”.

From a SDT point of view, for log d2’ scores [37, 54] H, FA, CR and M are computed as follows: accurate responses on expectancy discrimination (Type I Hits or Correct rejections) accompanied by a confident response are considered as Hits. Incorrect responses (Type I False Alarms or Misses) with high confidence as False Alarms. Correct Rejections are incorrect responses rated with low confidence, and Misses are accurate responses rated with low confidence.

Logistic d2’ and SE d2’ were obtained using the same method as previously described.

A Bayes factor was then computed for each participant on their log d2’, modelling H1 with a Uniform going from 0 to their own log d1’ as a maximum, given that d2' rarely exceeds d1’ [50]. Participants with a $B>3$ were categorized as metacognitively Aware, those with $B<1/3$ as metacognitively Unaware, and the rest had an undetermined metacognitive state.

The mean log d1's of metacognitively Aware participants was then used as the maximum for a Uniform to model H1 for testing each individuals d1's to determine their CA, [50]. The interpretation of individual *Bs* was then used to categorize them as contingency Aware, Unaware, or undetermined.

3.2.7.3 Post-hoc contingency measurement:

Data extracted from Post-hoc contingency measurements was analysed, as in Experiment 1, performing independent samples t-tests on HR and LR stimuli compared to 5 (rating indicating “I don’t know”).

3.2.7.4 Emotional Attentional Blink:

For Aware and Unaware participants, a 2-way Repeated measures ANOVA was conducted on accuracy to detect the targets, with CS targets (HR vs LR) and distractor type (aversive vs. neutral) as within factors. Sample sizes and variances differed between groups and therefore no between group comparisons were performed (Levene’s for HR neutral with distractors, $F(1,41)=7.013$, $p=.011$, LR with negative distractors, $F(1,41)=7.181$, $p=.011$). We hypothesized the same results as in Experiment 1, detection of LR targets would be affected by aversive distractors compared to neutral, and detection of HR would not be affected by distractor type. We also explored differences between HR and LR targets under baseline condition (neutral distractors).

3.2.7.5 Pleasantness:

A paired samples t-test compared pleasantness towards HR and LR stimuli for Unaware and Aware participants separately. No between group comparisons were performed as sample sizes and variances were different between groups, Box M $F(3,21531)=7.071$, $p<.001$.

3.2.7.6 Supplementary analyses:

RT towards HR and LR stimuli during conditioning were log transformed in order to compare them. Paired samples t-tests were performed for Unaware and Aware participants.

Accuracy towards HR and LR stimuli was compared within Aware and Unaware participants as well as Type 2 d’ scores. Results are reported on Appendix B.

3.3 RESULTS:

3.3.1 Contingency Awareness:

Using the Bayesian approach for metacognitive CA using log d2’ scores, 27 participants were deemed sensitively meta-unaware, 30 didn’t show any sensitive results ($3<B>1/3$), and 3

participants were categorized as metacognitively Aware. Using the mean log d1' score of metacognitively participants as prior (2.72) to establish CA, 28 participants had a sensitive null on log d1' and were effectively contingency Unaware, 6 of them being metacognitively insensitive. Fifteen participants were deemed as contingency Aware, 3 of them belonging to the metacognitive Aware group, 1 of them to the metacognitively Unaware group, and 11 having insensitive log d2' scores.

Another 17 participants had an insensitive log d1', their CA could not be established and will be excluded from further analyses, see Table 1. For further analysis, results will be reported for contingency Aware and Unaware participants, avoiding differentiating them in terms of metacognitive knowledge due to the small sample size of meta-aware participants and the high number of insensitive ones.

		Type I: Contingency Awareness			
		Unaware	**Insensitive**	**Aware**	
Type II: Metacognitive Knowledge	**Unaware**	22	4	1	27
	Insensitive	6	13 **(1)**	11 **(9)**	30
	Aware	0	0	3 **(2)**	3
		28	17	15	60

Table 1: *Contingency table presenting the categorization of participants according to the results on their individual Bayes Factors for Type I outcome-Contingency Awareness and on Type II tests of Metacognitive Contingency Awareness.* (***x)*** *participants deemed Contingency Aware via post-hoc categorization.*

3.3.2 Post-hoc Contingency Awareness:

Out of 60 participants, 12 were deemed Aware following the procedure on Experiment 1, eleven of them being Contingency Aware according to Bayesian analyses and one having originally an insensitive *B*. Four participants did not pass the post-hoc categorization, implying that some forgetfulness might have occurred over time, but generally confirming that the two measurement methods are congruent (see Table 1).

3.3.3 Emotional Attentional Blink:

For the Unaware group, there was a main effect of distractor type on accuracy, $F(1,27)=8.064$, $p=.008$. No significant interaction between target and distractor type, $F(1,27)=1.87$, $p=.183$, was found. However, due to the hypothesized effects and taking into account the results obtained on Experiment 1, we performed planned paired samples t-tests.

In the Unaware group aversive distractors decreased detection of LR stimuli, $t(27)=2.668$, $p=.013$ compared to neutral distractors. Distractor type did not have any significant effect on detection of HR stimuli, $t(27)=.-052$, $p>.9$, see Fig. 8. There were no significant differences between HR and LR targets under neutral distractors, $t(27)=-.729$ $p=.472$.

These results show again that stimuli conditioned with HR are less affected by the interference of aversive distractors than LR stimuli for Contingency Unaware participants.

For Contingency Aware participants, there was again a main effect of distractor type, $F(1,14)=11.760$, $p=.004$ but no significant interaction between stimulus and distractors, $F(1,14)=2.484$, $p=.137$. Here aversive distractors decreased detection of HR compared to neutral distractors, $t(14)=4.185$, $p=.001$. There was no significant effect of distractor on LR target detection, $t(14)=-.574$, $p=.575$, see Fig. 8. There was finally a marginally significant difference between HR and LR targets under neutral distractors, $t(14)=1.966$, $p=.069$.

3.3.4 Pleasantness:

Results show that HR stimuli (mean=.55, SD=.17) were more pleasant than LR (mean=.49, SD=.17), $t(42)=2.276$, $p=.028$ collapsing both groups. Analysing separately Aware and Unaware participants, a marginal increase in pleasantness towards HR stimuli compared to LR for Aware participants, $t(14)=1.830$, $p=.089$ was found. The difference was even weaker for Unaware participants, $t(27)=1.545$, $p=.134$, Fig. 7.

3.3.5 Questionnaires:

There were no corrected significant differences between Unaware and CA groups in the questionnaire scores (see Table B.1 in Appendix B).

3.3.6 Supplementary analyses:

No significant differences were found, see Appendix B.

3.4 DISCUSSION EXPERIMENT 2:

Measures of metacognitive awareness incorporated in this experiment gave rise to 3 distinct groups. As expected, participants were categorized as Unaware of the contingencies, as partially Aware, being able to predict the outcomes associated with CSs; and metacognitively Aware, having developed metacognitive knowledge about contingencies. Bayes factors were used to perform this classification, a vital step when determining the existence of unconscious processes. One of the limitations of this analysis is the fact that many participants showed insensitive results, and couldn't therefore be correspondingly classified.

Importantly, we replicated the results obtained on the EAB in Experiment 1. We failed at obtaining heightened emotional responses towards HR stimuli for Unaware and Aware participants separately. However, when considering all participants, HR stimuli were more pleasant than LR. This finding shows that abstract stimuli can acquire emotional salience with conditioning, and partly helped in overcoming the limitations of Experiment 1 in relation to the intrinsic nature of stimuli used.

4. GENERAL DISCUSSION:

Both experiments showed that expectancy awareness is not necessary to generate preferential attention towards CSs. During an EAB task, detection of stimuli associated with LR but not HR probabilities decreased in the presence of aversive emotional stimuli as distractors. That occurred both in Experiment 1 (all participants were unaware) and in Experiment 2 only in participants who were Unaware, and not in those who were Aware of the contingencies. Importantly in Experiment 2 awareness criteria were more rigorous. The ability of HR stimuli to overcome the interference of aversive distractors as opposed to LR stimuli is a proof that attention was preferentially allocated towards HR stimuli. These findings taken together provide a first strong account of a implicitly conditioned attentional response using an EAB task [28].

In experiment 2 the number of participants with awareness of stimulus-outcome contingencies increased allowing us to examine how attention developed in Aware participants. During the EAB, Aware participants seemed to allocate more attention to LR stimuli, as attention to LR targets was not affected by aversive distractors; however attention to HR stimuli was affected by aversive distractors, implying a decrease in attention allocation to HR stimuli for those participants. This might be explained by differences in the predictive power explicitly obtained by CS.

According to the Pearce-Hall theory of attention [60], it is possible that the increased predictability of HR stimuli in Aware participants leads to a decreased necessity to focus attention on HR stimuli [61], in order to perform accurately, leading to a higher effect of interference by the salient negative distractors (but also to a marginal higher accuracy in the

presence of neutral distractors (compared to LR)). On the other hand, for Unaware participants, for which knowledge about stimuli paired with reward is obviously not sufficient to generate correct predictions, the valence obtained by CS through non explicit associations drives their attention preferentially towards HR CS, in accordance with Mackintosh's theory [62] of associative learning. Such an explanation could be supported by the fact that Aware and Unaware participants combined showed pleasantness towards HR over LR stimuli (main effect of stimulus, p=0.028), a measurement of the emotional value of HR stimuli. However when the two groups were separately analyzed, both demonstrated a marginal effect, although stronger for Aware participants. Of course this explanation should be taken into consideration with caution as our data did not demonstrate any difference of contingency awareness between HR and LR stimuli; and our data on pleasantness were not as clear for Unaware participants. More research on how metacognition about stimuli-reward associations and emotional and attentional responses to stimuli associated with reward develops may help to integrate both theories [63] and support an understanding on attentional and emotional conditioned responses.

During our first experiment, HR CSs were not evaluated as more pleasant than LR stimuli, inconsistent with previous research [21]. However, a series of factors could have affected the pleasantness ratings. Firstly, stimuli depicting Houses and Buildings were used in Experiment 1. Even though independent measures carried out in a pilot study had discarded a preferential hedonic appraisal of any of the two categories, after conditioning, Houses were evaluated as more pleasant than Buildings, even when the latter stimulus type was associated with higher probabilities of obtaining money. In previous studies when houses and buildings were used as CSs [28], pleasantness ratings were not taken at the end of the conditioning task. During the second experiment, abstract geometric stimuli were used as CSs. Those stimuli were specifically crafted to prevent them from generating any intrinsic emotional reactions [64–66]. This time, stimuli associated with HR were consistently more pleasant than those associated with LR if considering the whole sample. These differences highlight one of the limitations of stimuli used in experiments evaluating preference towards drug cues, as the graphic nature of those stimuli can hinder their ability to generate automatic implicitly learned reactions. These findings also point out the importance of using neutral stimuli in conditioning paradigms (i.e. stimuli with no possible previous value).

Another reason why Experiment 1 may have failed at generating preferential hedonic reactions towards HR stimuli is the fact that pleasantness was measured after the EAB task. This means that CSs had been extensively presented under extinction, as during EAB trials there was no reward following CS presentation. It is possible that the effects of conditioning in Unaware participants were not strong enough to withstand that kind of extinction procedure, explaining why the intrinsic value of the images took over during the pleasantness evaluation task. On Experiment 2, pleasantness was measured between the conditioning and EAB tasks, and thus that may contribute to the task generating the expected results.

Importantly, in Experiment 2 higher pleasantness for HR over LR was found, but not for Unaware participants in isolation, failing to support previous findings [21].This is in line with previous data showing that CA was necessary for the generation of emotional responses [7], but still cannot rule out the ability of Implicitly conditioning to generate hedonic responses, as a very marginal effect was seen also in unaware participants and as mentioned above a main stimulus effect was highly significant.

Regarding, the EAB for Unaware participants, we find in both experiments that LR stimuli are less detectable in the presence of aversive distractors than neutral, whereas HR stimuli were not. However these effects were more pronounced in Experiment 1. It is possible that these effects were weaker in Experiment 2 due to an effect size (n=43 in experiment 1 and n= 28 in experiment 2) or due the fact that EAB was measured later on in the procedure (after the measurements of pleasantness) pointing again towards a possible effect of extinction.

A recent experiment by Le Pelley et al. [67] showed using a RSVP task that distractors associated with reward only affect target detection under conditions of CA, results that somehow clash with our findings. However, in their task, the conditioning procedure was embedded within the RSVP instead of occurring previously and separately. Moreover, CS in their case acted as distractors and not as targets. Their findings suggest that CA is necessary for conditioned stimuli during a learning task to affect target detection, whereas our findings suggest that CS paired with high reward probabilities can resist the interference of aversive distractors after a conditioning task.

Our procedure used money as reward, which may be considered not as high in value as primary reinforcers (e.g. food, drugs etc). However, as Hogarth at al. [35] already posited, conditioning procedures using tobacco or other substance administration as reward can lead to reduced reward value by the occurrence of satiety effects. Satiety decreases pleasantness attributed towards the substance itself [68]. It is possible that this decrease in pleasantness blocks the development of positive attentional responses towards CSs under conditions of Contingency Unawareness. Conditioning paradigms targeting the generation of implicit conditioned responses should therefore use rewards as outcomes for which satiation is difficult to achieve (i.e. money) instead of drug substances or food.

An important aspect of Experiment 2 is that a parsimonious analysis of CA using a statistical approach originating in Implicit learning theories [40] and recurring to Bayes factors [55] allowed us to classify participants in three different groups: those Unaware of the contingencies governing the conditioning task; those able to predict the outcomes associated with each CS; and those able to explicitly describe those contingencies. Most importantly, the rigorous classification obtained using Bayes factors allows determining the true nature of conscious or unconscious processes [50]. Post-hoc expectancy measurements using Likert scales were also compared to online measurements of awareness using d1' score categorizations. Interestingly, a high congruency between both kinds of methodologies was found. Arguments against the existence of Implicit conditioning are based often on the types of EA measurements used to classify awareness [19]. Our results show that a sensible approach towards EA measurements suffices in order to obtain reliable implicit measures.

This fact suggests that the problem underlying inconsistent results in the implicit learning literature [16, 19, 35] lays more within the kind of conditioning procedure or the type of stimuli used, or the measurement of learning by-products (i.e. conditioned emotional responses), rather than EA measurements.

We think that the separation of participants in three groups depending on their CA and metacognition is a useful tool to help us understand learning processes, and hence this rigorous methodology should be prioritised. In our conditioning the number of Aware participants was relatively small to obtain a better differentiation between these subgroups. It is possible that the small number of Aware participants is due to the use of a task-irrelevant conditioning task that may have impeded explicit learning.

A high proportion of participants could not definitely be classified as Aware or Unaware of contingencies on Experiment 2. Their metacognitive state was also undetermined due to their Bayes factors for both measurements being insensitive. As learning is a progressive phenomenon, initial trials are uninformative of contingency knowledge compared to later blocks. In this experiment EA was measured every 4 trials so as to prevent excessive priming of awareness development [19]. Those two factors combined lead to a small amount of trials being used for awareness categorization, and therefore generated a higher rate of insensitive results.

In summary, this paper shows convincing evidence of the occurrence of Implicit Pavlovian conditioning whilst presenting a novel approach of CA measurement based on Bayes factors. It suggests that appetitive CSs can elicit increased attention in conditions of contingency unawareness. The attentional correlates of implicit learning appears to match those generated by explicitly learned appetitive CSs as reported in the literature. Our data also

indicated a development of implicit emotional response albeit not as clearly. These findings therefore highlight a possible role of implicit learning in the development of addictive behaviours and support dual process theories of addiction. More research needs to address the development of emotional responses in implicit conditioning, as results have proven to be inconclusive.

The utility of the emotional and attentional responses to stimuli associated with reward for seeking that reward (i.e. the behavioural response) in the absence of awareness remains to be shown.

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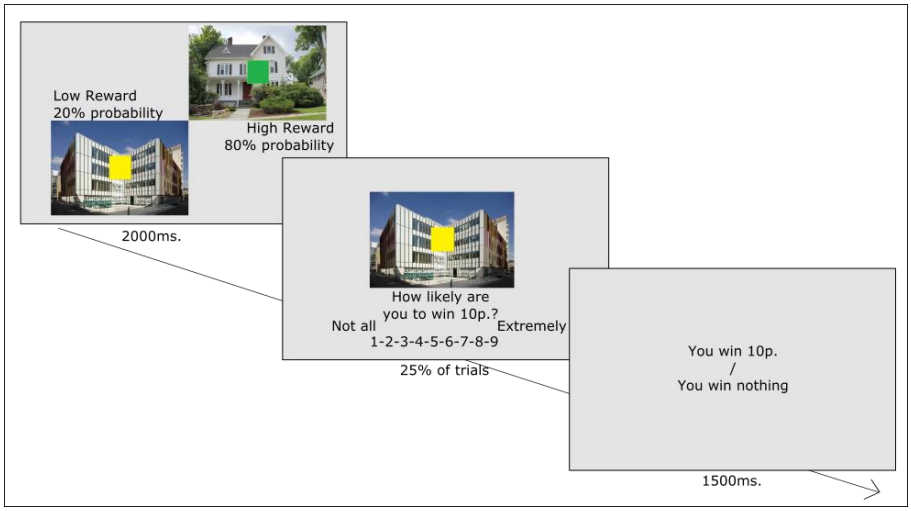
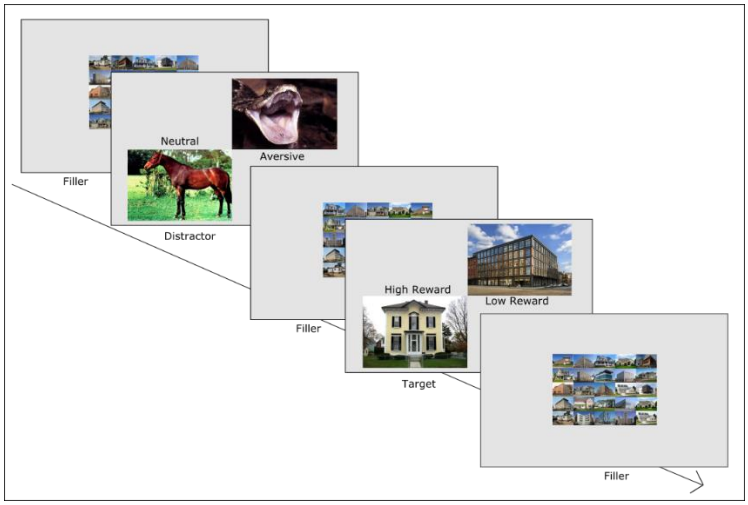

Low Reward
20% probability
High Reward
80% probability
2000ms.
How likely are
you to win 10p.?
Not all
1-2-3-4-5-6-7-8-9
Extremely
25% of trials
You win 10p.
/
You win nothing
1500ms.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Distractor
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Low Reward
Target
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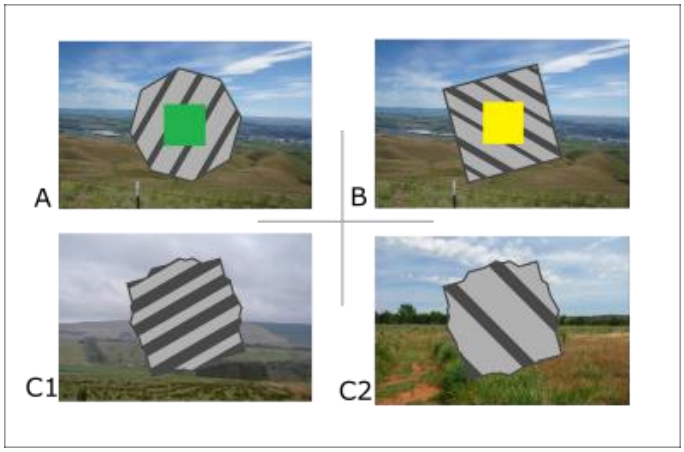
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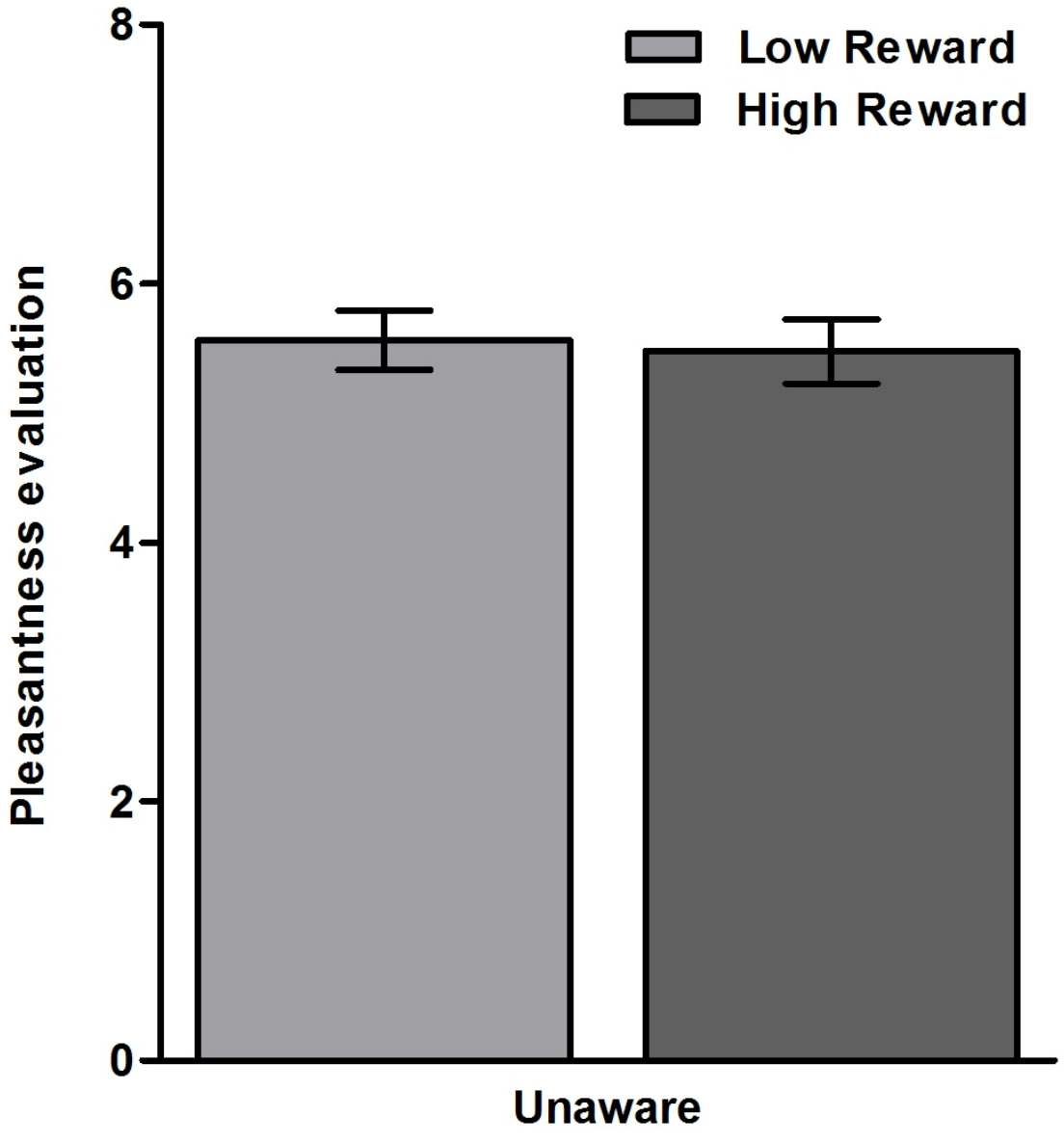
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Pleasantness evaluation
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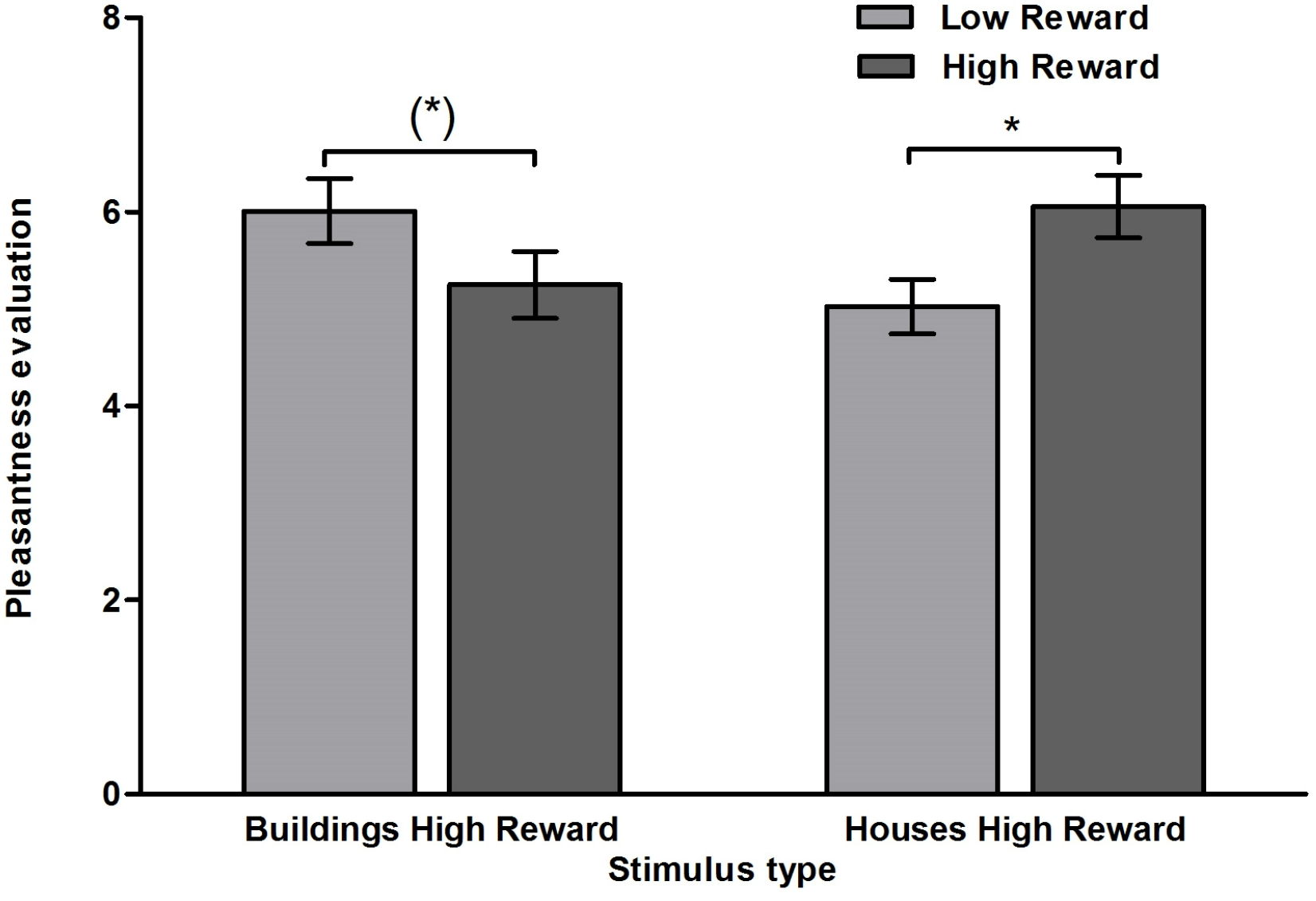
Unaware


Low Reward
High Reward
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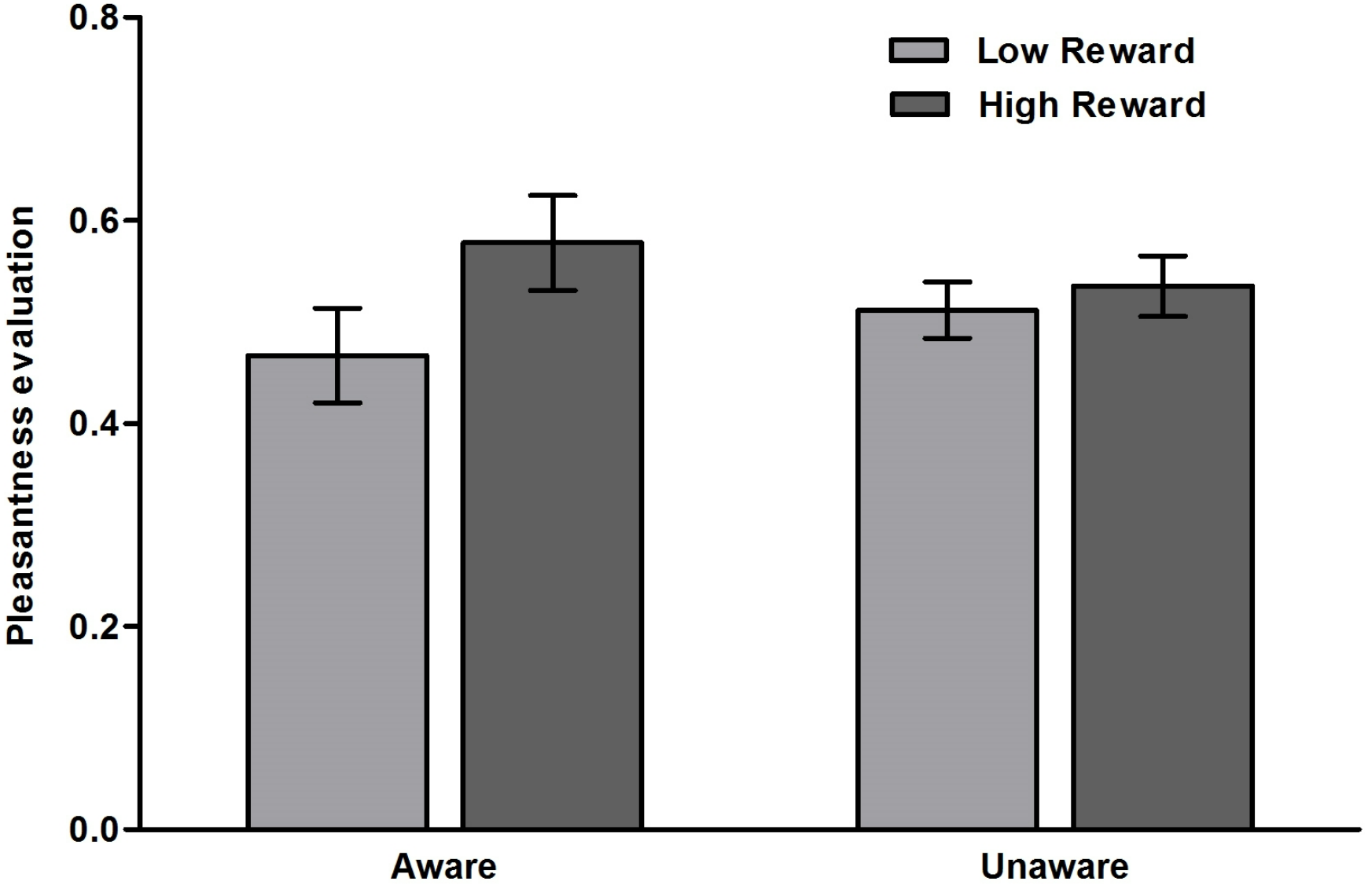
Pleasantness evaluation
Buildings High Reward
Houses High Reward
Stimulus type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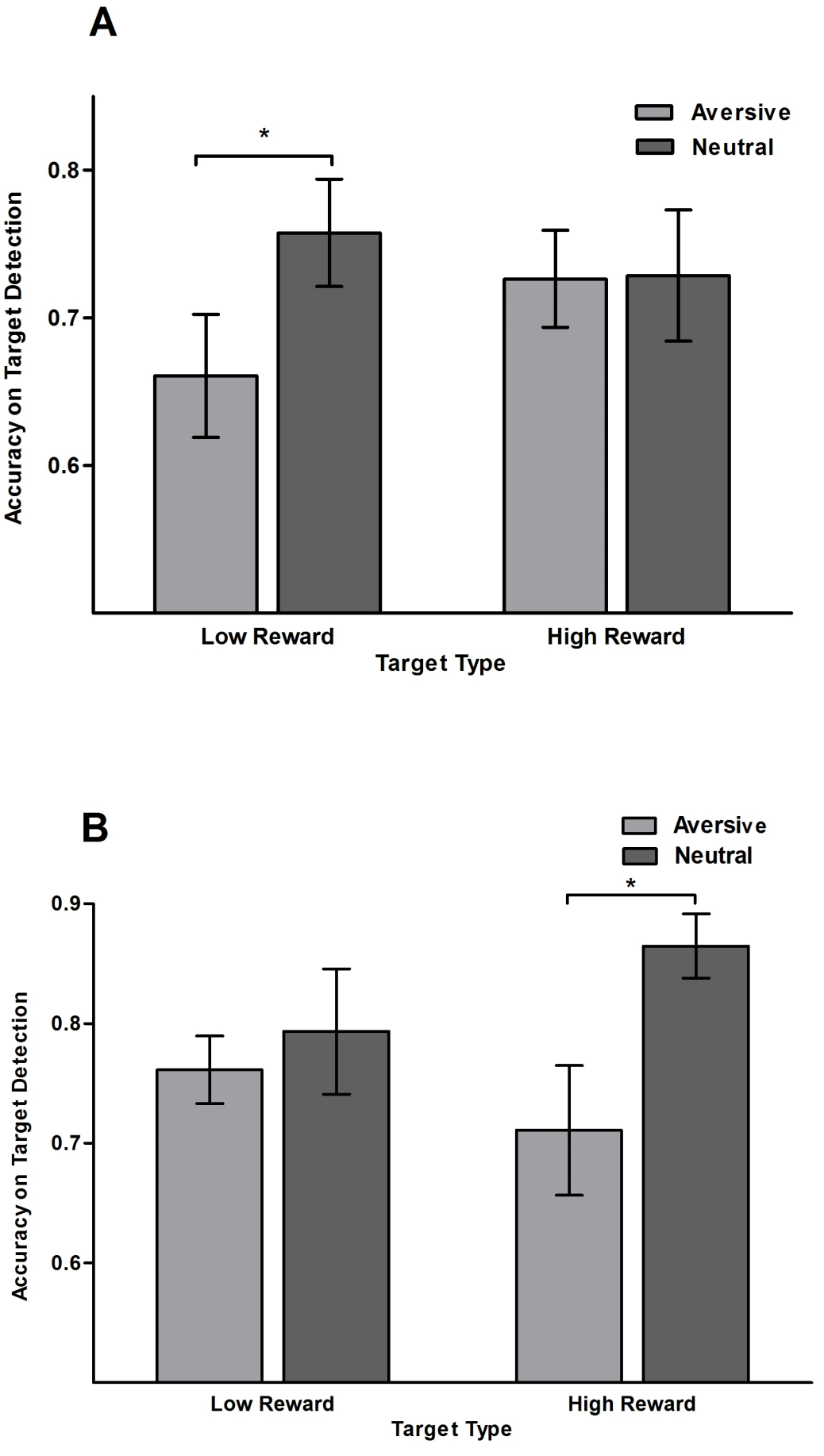
0.6
0.4
0.2
0.0
Pleasantness evaluation
Low Reward
High Reward
Aware
Unaware


A
Aversive
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Accuracy on Target Detection
Low Reward
High Reward
Target Type
B
Aversive
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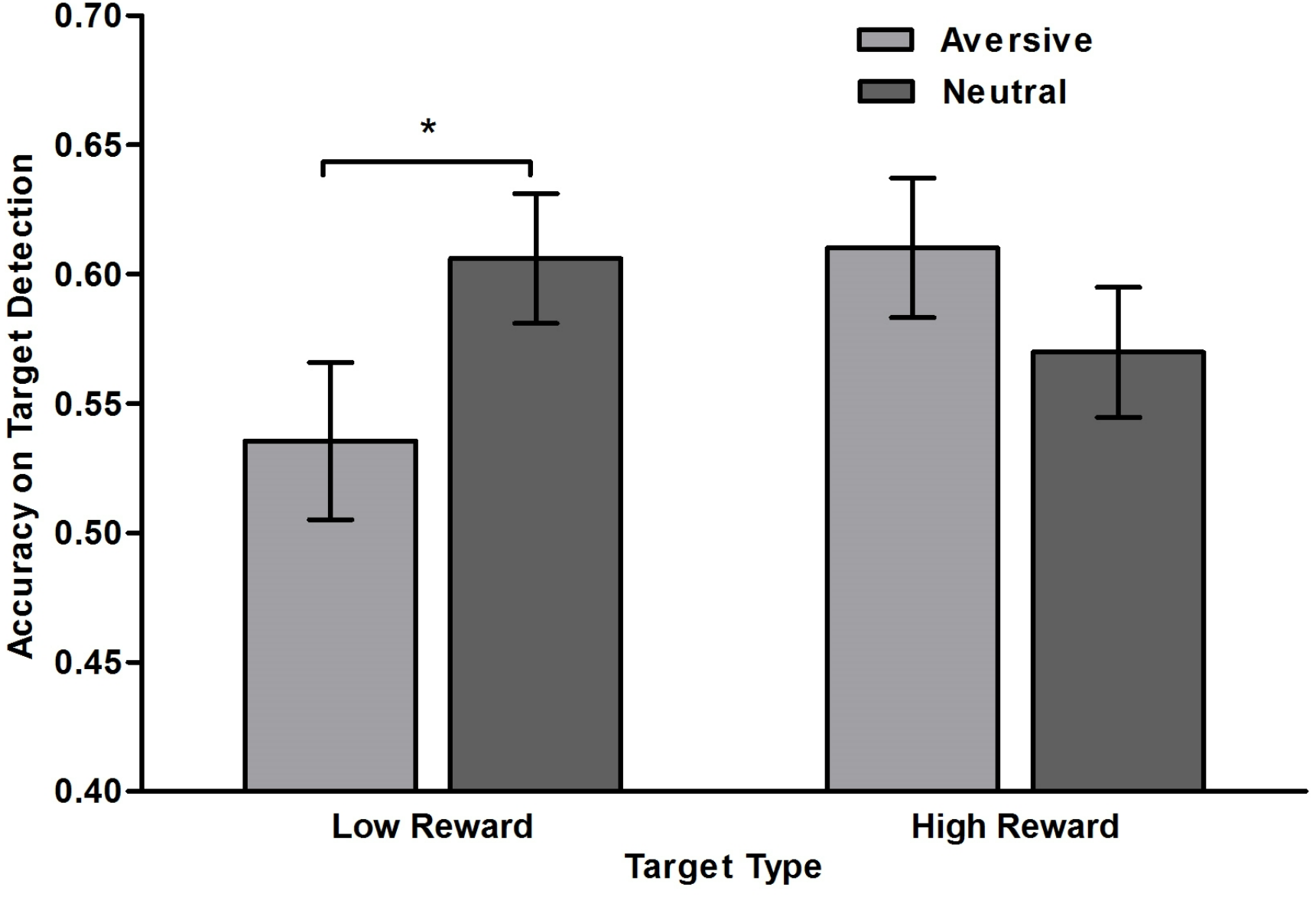
*
0.9
0.8
0.7
0.6
Accuracy on Target Detection
Low Reward
High Reward
Target Type


0.70
0.65
0.60
0.55
0.50
0.45
0.40
Accuracy on Target Detection
Aversive
Neutral
*
Low Reward
High Reward
Target Type

Appendix A:

Table A.1

Data for demographic and questionnaire information for Experiment 1 depending on Awareness group and statistics for ANOVA comparing Contingency Aware and Unaware groups.

	Unaware n= 44		Aware n=4			
	Mean	SD	Mean	SD	*F*	*p*
Age	23.43	7.32	28.00	13.59	1.23	0.27
Panas positive	2.90	0.79	2.65	1.49	0.32	0.58
Panas negative	1.52	0.48	1.30	0.42	0.76	0.39
BIS	2.82	0.32	3.00	0.42	1.09	0.30
BAS	2.96	0.41	2.90	0.53	0.07	0.80
BAS Drive	2.74	0.64	2.75	0.74	0.00	0.99
BAS Reward	3.35	0.44	3.65	0.25	1.80	0.19
BAS Fun seeking	2.79	0.68	2.31	0.75	1.78	0.19
Barrat Total	2.15	0.41	1.71	0.26	4.34	0.04
Barrat Attentional	2.24	0.48	1.81	0.33	2.99	0.09
Barrat Motor	2.04	0.44	1.66	0.33	2.83	0.10
Barrat Nonplanning	2.16	0.52	1.66	0.30	3.54	0.07
Alcohol Use Total	29.92	24.67	8.45	10.46	2.93	0.09
Binge score	20.20	17.36	3.38	4.03	3.67	0.06
Alcohol units/week	9.71	9.94	5.08	6.47	0.83	0.37
AUDIT	7.98	6.16	2.75	3.40	2.76	0.10

Experiment 1

Pleasantness for Aware participants:

For the four Aware participants, pleasantness towards HR (mean=6.97, SD=.89) and LR (mean= 5.74, SD=1.43) stimuli was computed.

Emotional Attentional Blink for Aware participants:

For the four Aware participants, accuracy on the EAB was computed. Under neutral distractors, HR stimuli had an accuracy of .67 (SD=.08) and under aversive distractors of .73 (SD=.09). Under neutral distractors, LR stimuli had an accuracy of .55 (SD=.20) and under aversive distractors of .39 (SD=.20).

RT during the conditioning task:

Results show no significant differences in RT towards HR and LR stimuli for Unaware participants, there was only a marginal difference, with increased RT towards HR stimuli (mean=2.67, SD=.08) than LR (mean=2.66, SD=.08), $t(43)=1.705$, $p=.095$. For Aware participants, RT towards HR stimuli were 2.74 (SD=.16) and LR stimuli were 2.74 (SD=.16).

Appendix B:

Experiment 2

Table B.1

Data for demographic and questionnaire information for Experiment 2 depending on Awareness group and statistics for ANOVA comparing Contingency Aware and Unaware groups.

	Unaware n= 28		Aware n=15			
	Mean	SD	Mean	SD	F	p
Age	20.50	4.10	20.60	1.99	.008	.930
Panas positive	2.76	0.75	3.01	0.65	1.248	.270
Panas negative	1.44	0.41	1.57	0.52	.770	.385
BIS	1.60	0.35	1.89	0.44	5.837	.020
BAS	2.03	0.28	2.05	0.22	.056	.814
BAS Drive	2.35	0.42	2.32	0.55	.044	.834
BAS Reward	1.64	0.33	1.60	0.33	.114	.737
BAS Fun seeking	2.21	0.50	2.35	0.47	.861	.359
Barrat Total	2.02	0.23	2.11	0.27	1.401	.243
Barrat Attentional	2.12	0.43	2.09	0.44	.071	.791
Barrat Motor	1.90	0.30	2.00	0.42	.780	.382
Barrat Nonplanning	2.06	0.27	2.15	0.42	.773	.385
Alcohol Use Total	28.40	19.64	32.57	27.28	.335	.566
Binge score	15.38	11.20	18.73	15.62	.663	.420
Alcohol units/week	13.02	13.63	13.84	13.39	.036	.851
AUDIT	6.36	4.35	7.93	5.39	1.085	.304

RT during the conditioning task:

Results show no significant differences in RT towards HR (mean=2.66, SD=.10) and LR (mean=2.66, SD=.10) stimuli for Unaware participants, $t(27)=.480$, $p=.635$. For Aware participants, there was no significant difference between HR (mean=2.70, SD=.09) and LR (mean=2.69, SD=.09) stimuli, $t(14)=.560$, $p=.584$.

Accuracy towards HR and LR stimuli:

There were no significant differences in accuracy towards HR and LR stimuli neither for Unaware, $t(27)=.055$, $p=.956$ (HR=.46, SD=.20; LR=.46, SD=.19), nor for Aware participants, $t(14)=.760$, $p=.460$ (HR=.89, SD=.15; LR=.85, SD=.18).

Metacognition towards HR and LR stimuli:

There were no significant differences in d2' scores towards HR and LR stimuli neither for Unaware, $t(27)=1.415$, $p=.169$ (HR=-.19, SD=.54; LR=.12, SD=.76), nor for Aware participants, $t(14)=.704$, $p=.493$ (HR=.1.08, SD=.77; LR=.89, SD=.87).

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Figure 1: Conditioning task.
Each trial consisted of the presentation of a House or a Building with an overlaid coloured square. For half of the participants, Buildings were associated with High reward (80% probability of wining 10p) and Houses with Low reward (20% probability). For the other half of the sample, probabilities were inverted across stimuli categories. Participants had to press a key depending on the colour of the square (Green/Yellow) in the middle of the picture. Stimuli appeared on screen for 2000 ms or until a response was given. After their response participants were informed whether they had won 10p or not on that trial. On 25% of the trials, right after their response, participants were asked to indicate from 1 = "not at all" to 9 "extremely" how likely they were to win 10p (measurement of Expectancy Awareness). Immediately after Expectancy Awareness measurement, feedback about earnings on that trial appeared on screen.

Figure 2: Emotional Attentional Blink.
Seventeen stimuli were presented in each trial on a RSVP stream for 83-100 ms each. The stimuli presented were a series of Fillers composed by jittered pictures of Houses and Buildings and an Aversive or Neutral distractor appeared on position 4, 6 or 8 of the series. After the distractor, a Filler was presented followed by a target consisting of a House or a Building. Finally, more fillers appeared to complete the 17 stimuli sequence. Participants' task was to indicate the detection of a House or a Building by pressing one of two keys at the end of the trial.

Figure 3: Accuracy of target detection (High reward or Low Reward) depending on Distractor type (Aversive or neutral), Experiment 1.
Accuracy on target detection depending on reward associated and distractor type for Unaware participants. * Low reward targets under aversive distractors compared to neutral distractors, $p<0.01$.

Figure 4: Pleasantness ratings depending on stimulus type for contingency Unaware participants, Experiment 1.
Pleasantness ratings towards High reward and Low reward stimuli for Unaware participants; there were no significant differences in either of the groups, $ps>0.7$.

Figure 5: Pleasantness ratings per stimulus category for Unaware participants, Experiment 1.
Pleasantness towards High Reward and Low reward CS depending on the stimulus (houses or buildings) associated with High reward. (*) Low reward compared to High reward when Buildings were High reward, $p<.02$; * High reward compared to Low reward when Houses were High reward, $p<.01$. Houses were overall more pleasant than Buildings (main effect of stimulus type).

Figure 6: Stimuli used on Experiment 2.
Stimuli (octagons and squares) chosen for Experiment 2 to replace Houses and Buildings used in Experiment 1. 36 Octagons (A) and 36 Squares (B) were used as Conditioned Stimuli. Those stimuli appeared on the Conditioning task and on the Emotional Attentional Blink. A set of 15 fillers combining the outline of Squares and Octagons was also developed (C1/ C2). All stimuli appeared overlaid on a picture showing a neutral landscape. This was set in order to match the visual characteristics of stimuli series during Emotional Attentional Blink between the two experiments. Aversive and Neutral distractors used during Emotional Attentional Blink in Experiment 2 were the same as the ones used in Experiment 1.

Figure 7: Pleasantness ratings depending on stimulus type and contingency awareness, Experiment 2.
There were no significant differences between High reward and Low reward stimuli in either Aware or Unaware participants, *ps*>.08. However a significant stimulus effect (*p*=0.28) was Found when the 2 groups were collapsed.

Figure 8: Emotional Attentional Blink results for Unaware (A) and Aware (B) participants, Experiment 2.
Accuracy on target detection depending on reward associated and distractor type for Unaware participants. A: * Low reward targets under aversive distractors compared to neutral distractors, *p*<0.025. B: * High reward targets under aversive distractors compared to neutral distractors, *p*<.001. There was a marginally significant difference between HR and LR targets under neutral distractors, *p*=.069